Supporting information for

Nature-inspired creation of robust free-standing electrospun nanofibrous membrane for efficient oil-water separation



Fig. S1 WCAs of (a) PI nanofibrous membrane modified with OTMS and (b) a glass slide coated by Fe³⁺-PA/OTMS.



Fig. S2 AFM topography images of (a) OTMS and (b) Fe^{3+} -PA/OTMS coating on glass slide. The root-mean-square (RMS) roughness was 60.8 and 545.5 nm, respectively.



Fig. S3 (a) FT-IR spectra (TGA curves (c) XPS spectra, and (d) XRD patterns of the pristine PI, the Fe³⁺-PA/PI and the Fe³⁺-PA/OTMS/PI nanofibrous membrane.

To investigate the transformation from the pristine PI membrane to the Fe^{3+} -PA/OTMS/PI membrane, the FT-IR spectra of the pristine PI, the Fe^{3+} -PA/PI membrane, and the Fe^{3+} -PA/OTMS/PI membrane were shown in Figure. S3a. Many typical functional groups of the pristine PI membrane, such as –COOH (1716 cm⁻¹), – CONH (1771 cm⁻¹) and C–N (1356 cm⁻¹), were detected in the spectrum of the pristine PI membrane. The main characteristic peaks at 1652 cm⁻¹ (the stretch vibration of P=Q groups which come from -HPO₄²⁻), 1100 cm⁻¹ (the characteristic peak of -HPO₄³⁻) and 1380 cm⁻¹ (the absorption peak of the triple substituted phenyl ring) appeared after Fe^{3+} -PA coated the PI membrane, confirming the successfully coating of Fe^{3+} -PA on the surface of PI fibers. Moreover, there exist the characteristic

adsorption at 1261 cm⁻¹ and 810 cm⁻¹ are attributed to the bending vibration of Si-CH₃ and stretching vibration of Si-O-Si bond. The abovementioned results demonstrated Fe³⁺-PA and OTMS were successfully functionalized the surface of PI fibers. The transformation from the pristine PI membrane to the Fe³⁺-PA/OTMS/PI membrane was further studied by thermogravimetric analysis (TGA, Figure. S3b). In the TGA curves of the pristine PI, the Fe³⁺-PA membrane, and the Fe³⁺-PA/OTMS/PI membrane, Negligible weight loss was observed by the TGA curve of the pristine PI membrane when heated before 530 °C (in nitrogen environment), indicting high thermal stability. However, the Fe³⁺-PA /PI membrane showed that the membrane decomposed at the temperature above 250 °C. Between 250 and 530 °C, the weight loss of the Fe³⁺-PA/PI and Fe³⁺-PA/OTMS/PI membrane were 10 % and 24%, respectively. Which was ascribed to the decomposition of the Fe³⁺-PA and Fe3+-PA/OTMS, respectively. The XPS spectra of the pristine PI membrane, the Fe³⁺-PA/PI membrane, and the Fe³⁺-PA/OTMS/PI membrane are shown in Figure. S3c. In the XPS spectra of the pristine PI membrane, the Fe³⁺-PA/PI membrane, and the Fe³⁺-PA/OTMS/PI membrane, the C_{1s} (285 eV), O_{1s} (532 eV) and N_{1s} (399 eV) were detected. After Fe³⁺-PA treatment, new peak of Fe2p (745 eV) was observed and the signal intensities of the N_{1s} decreased due to the lower N atomic fraction Fe³⁺-PA than that of the original PI membrane, confirming the coverage of Fe³⁺-PA on the PI membrane surface. After the further modification by OTMS, there are obvious new peaks, Si_{2s} (100.4 eV) and Si_{2p} (167.7 eV), were observed. Figure. S3d shows the XRD diffraction patterns of the pristine PI, the Fe³⁺-PA/PI membrane and the Fe³⁺-PA/OTMS/PI membrane. Note that the three curves are similar, implying the surface modification had little effect on the fiber pattern. This unchanged fiber pattern after modification is necessary for making a stable superhydrophobic membrane used in oil-water separations.



Fig. S4 SEM images for Fe^{3+} -PA/OTMS/PI membranes after the separation of different oil-water mixtures. (a, a₁) Dichloromethane-water, (b, b₁) Trichloromethane-water, (c, c₁) Dichloroethane-water, (d, d₁) Bromobenzene-water and (e, e₁) Tetrachloromethane-water. a₁, b₁, c₁, d₁ and e₁ are the high-magnification image of a, b, c, d and e.



Fig. S5 WCAs of Fe^{3+} -PA/OTMS/PI membranes stored for about three months at room temperature nanofibrous membranes stored for about five months at room temperature.



Fig. S6 Photographs of one cycle of the sandpaper abrasion test.



Fig. S7 SEM images of Fe^{3+} -PA/OTMS/PI nanofibrous membrane after ten times abrasions using different meshes of sandpaper.



Fig. S8 Flux (a) and separation efficiency (b) of Fe^{3+} -PA/OTMS/PI nanofibrous membrane with ten times abrasions using different meshes of sandpaper.